Investigation Extreme Events using an Integrative Analysis of Observations

Two golden years occurred over the SGP: 2006 drought and 2007 flood contrast

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NASA ENERGY AND WATER CYCLE STUDY

NEWS

Motivation

Hydrological years 2006 (HY06, 10/2005-09/2006) and 2007 (HY07,10/2006-09/2007) are defined as "two golden years" in this study based on the following reasons:

1) There are no examples, to date, with such two highly contrasting extremes within two consecutive years.

2) No such a comprehensive dataset available concerning the droughts and floods in the SGP relative to other periods in history.

To investigate these two golden years, we have collocated ARM ground-based, NEXRAD, Oklahoma Mesonet, and GPCP and TRMM satellite data, as well as NCEP reanalysis over the SGP.

Data sets collected for this study

Time period: From January 1997 to December 2007

Spatial Domain: Entire Oklahoma, including ARM SGP

Data sets: (Observed or derived)

1) ARM:

Cloud fraction and thickness derived from radar-lidar paired measurements

Cloud LWP retrieved from microwave radiometer brightness Temp.

Rain rate measured by Tipping bucket rain gauge

SW/LW radiative fluxes measured by PSP and PIR radiometers

2) NEXRAD (precipitation Doppler radar): To study the vertical/horizontal/3D structures of Deep Convective Clouds/Precipitation

3) Oklahoma Mesonet rain gauge: To quantify the accumulated precipitation for each event and monthly accumulation

4) GPCP and TRMM precipitation over a 5x5 degree box centered on the SGP

5) NCAR/NCEP reanalysis: To investigate the role of large-scale dynamics in controlling the 2006 dry and 2007 wet events?

Objective

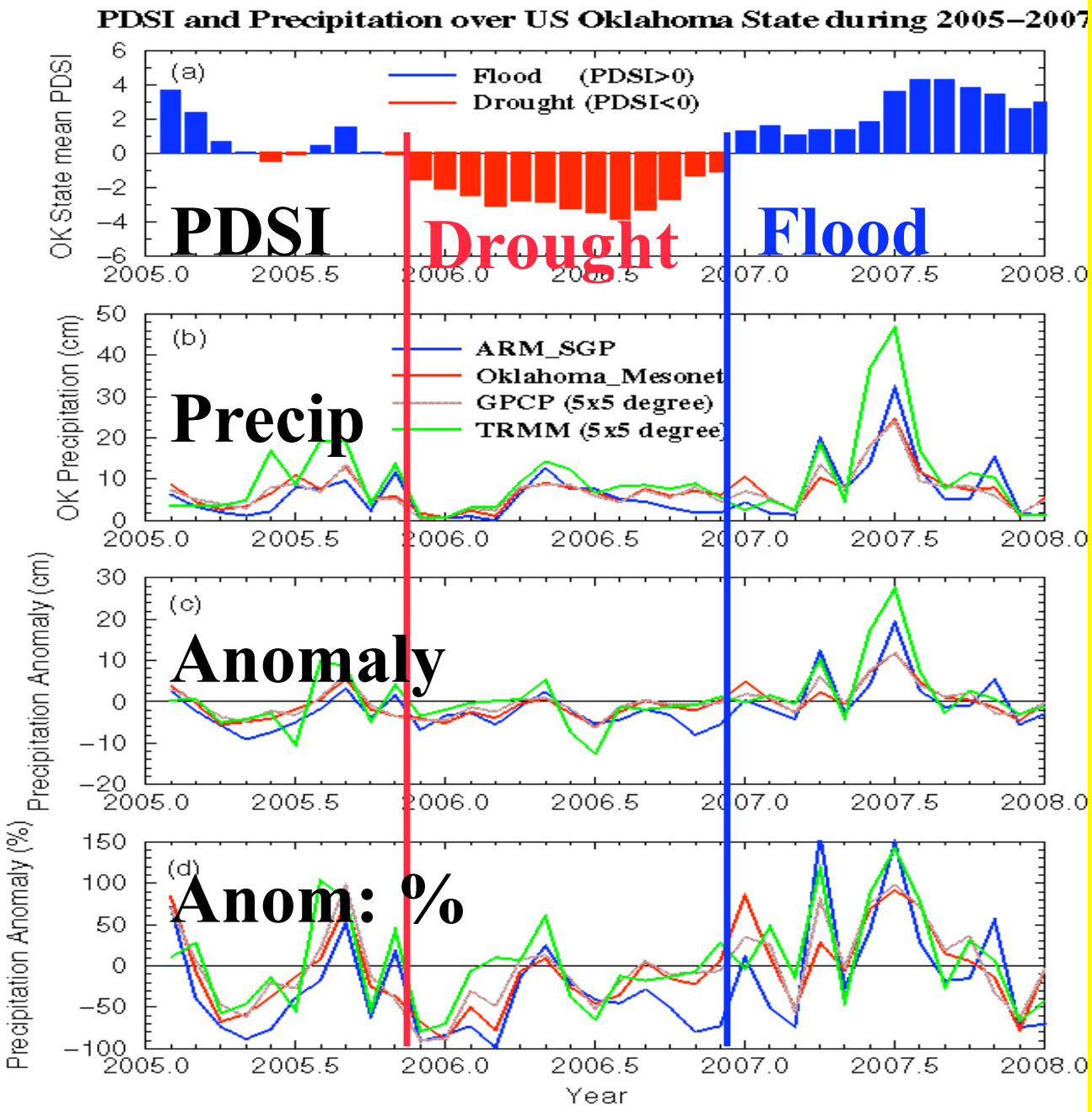
To understand the mechanisms responsible for water and energy extremes (drought and flood) in the U.S. SGP during 2006-2007, including their relationships with continental and global scale processes, and to assess their predictability and feedbacks on multiple space and time scales.

Scientific questions to address

1. Are HY06 and HY07 significant drought and flood? If yes, what are their severities in spatial and temporal variability?
2. What are the annual cycles of observed cloud-radiation-precipitation in HY06 and HY07?
3. To what extent do the large-scale dynamics play a role in controlling the SGP extreme events?
4. How do the SGP extreme events link with the tropical east Pacific SST and precipitation anomalies?

Question 1

1. Are HY06 and HY07 significant drought and flood? If yes, what are their severities in spatial and temporal variability?



a) PDSI values show HY06 is dry and HY07 is wet

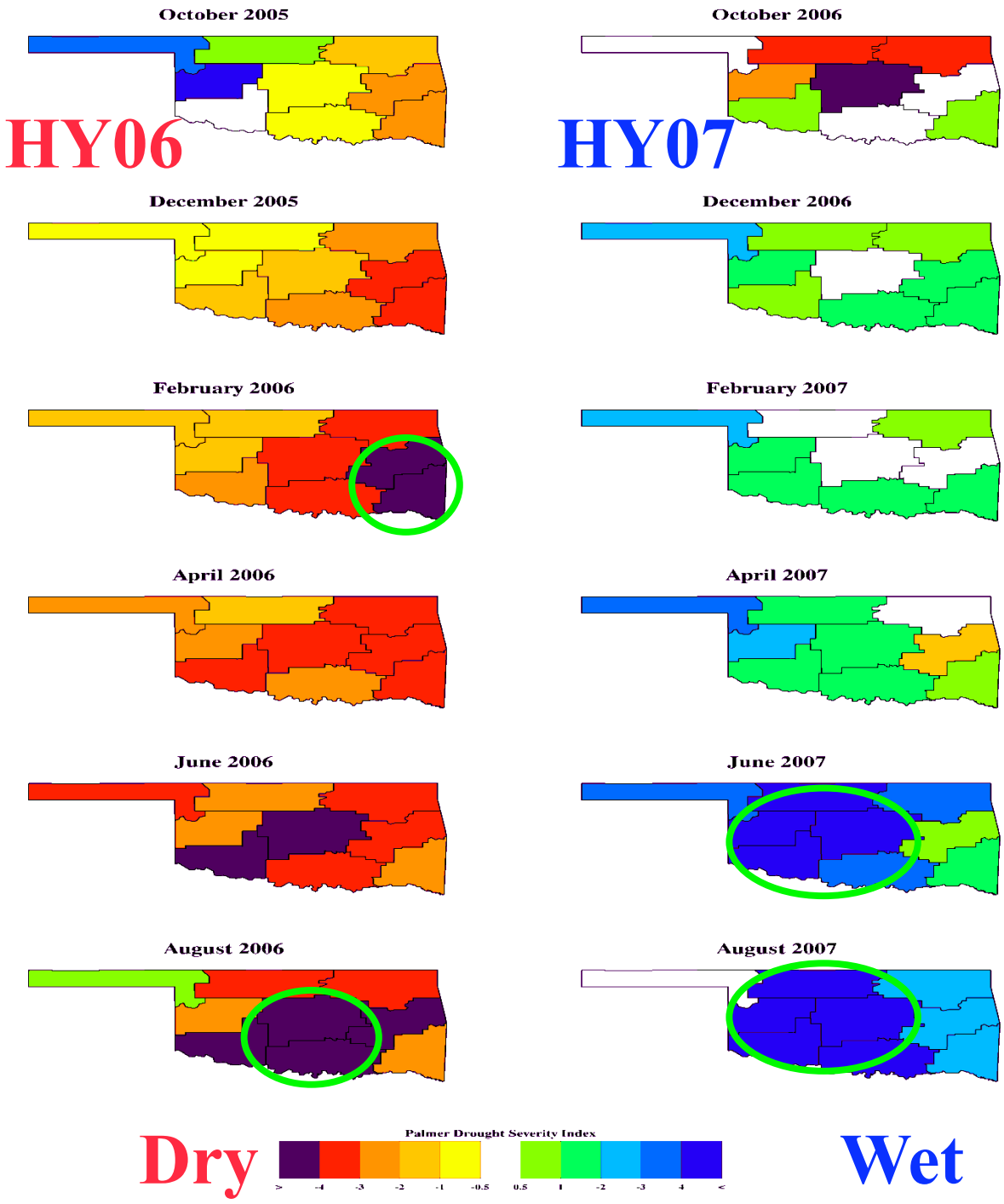
b)-d) Four precipitation datasets show:

HY06 is below the climate mean, especially during 11/2005-02/2006

➔extreme dry period

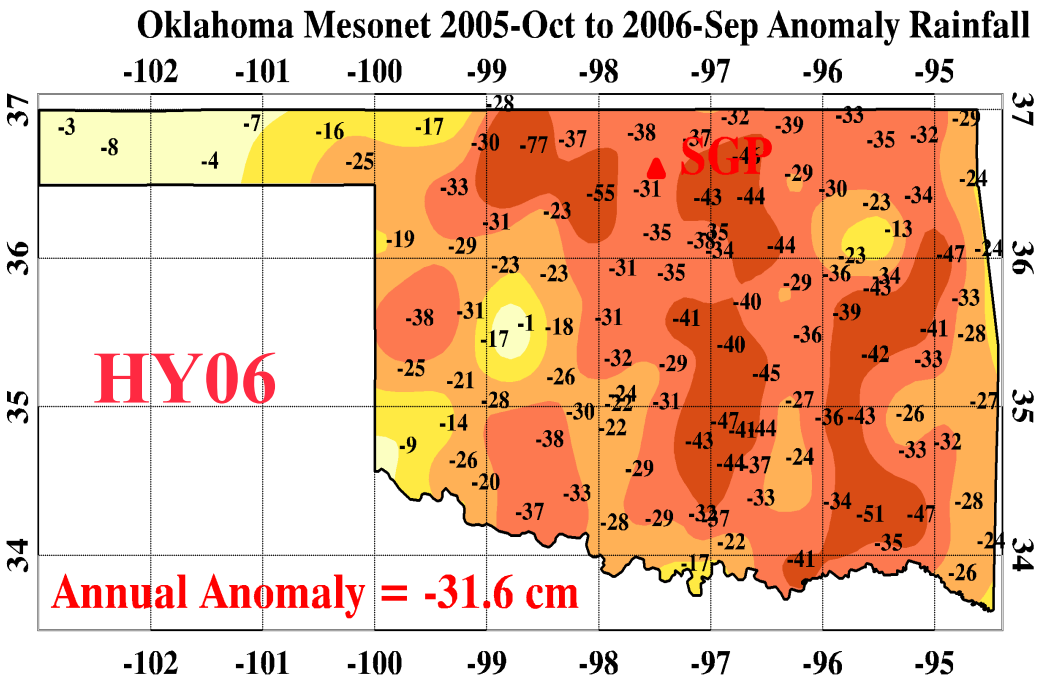
HY07 is above the climate mean, especially May-July 2007

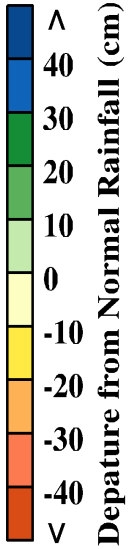
➔extreme wet



NOAA PDSI

- **Droughts occurred statewide during HY06 with severe and extreme droughts over southeastern and southern regions of OK.**
- **The floods during HY07 were also statewide, but severe and extreme floods occurred over central OK during summer.**

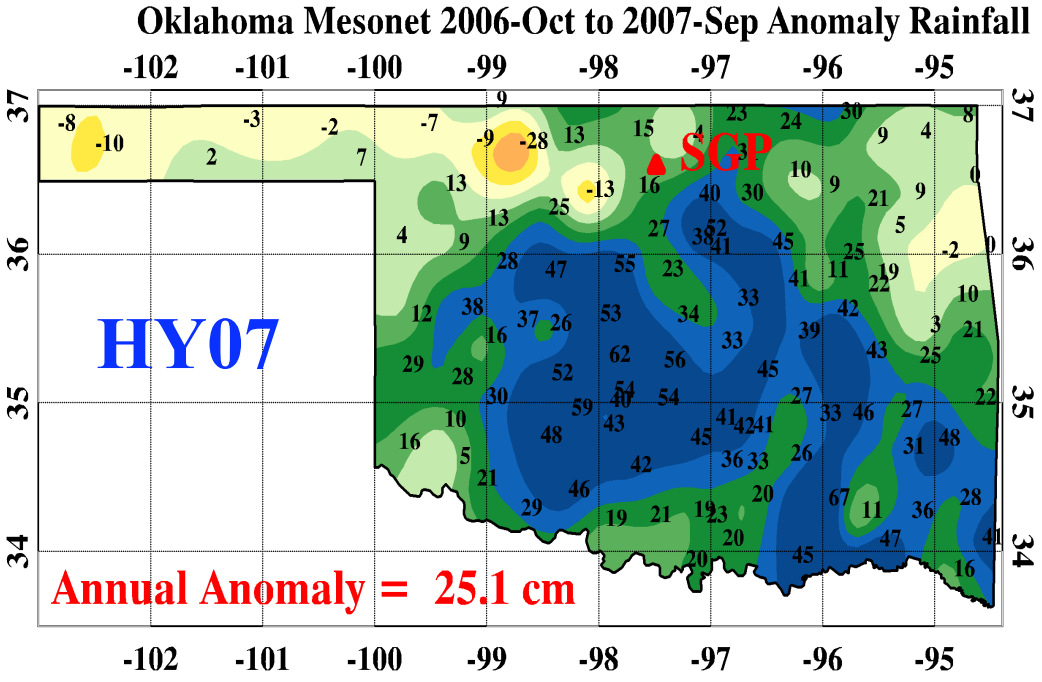


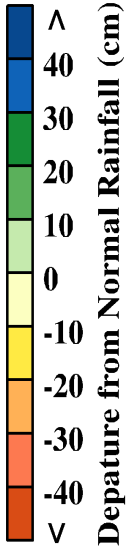


Answer to Question 1

➔HY06 ranks as second-driest year over entire OK state.

➔HY06 precipitation is 32 cm below mean

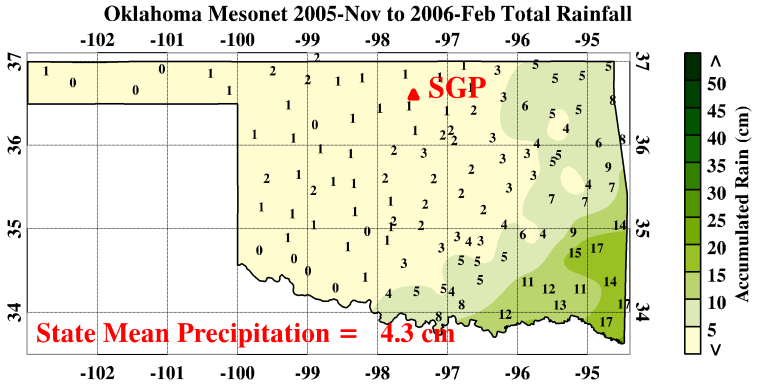


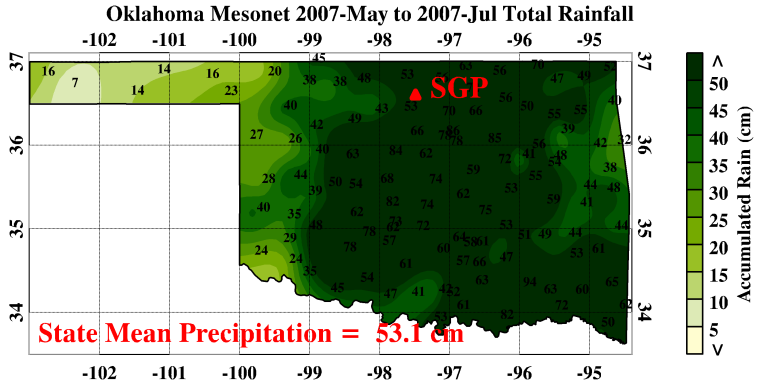


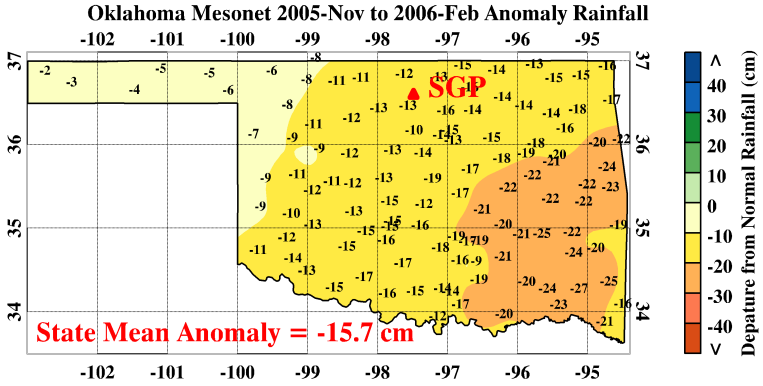
➔HY07 is seventh-wettest year over OK statewide and the wettest year over central OK.

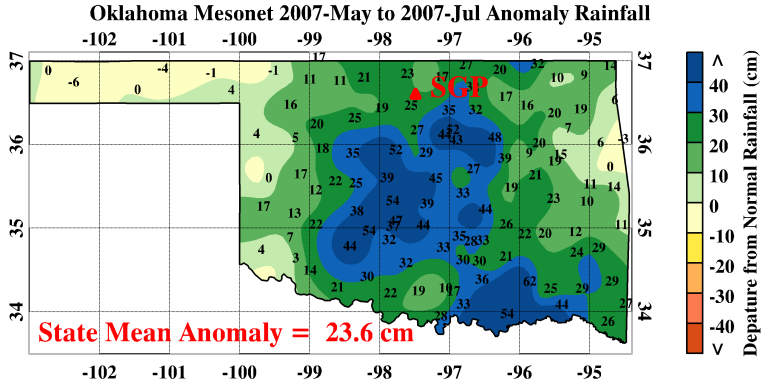
Winter 05-06 is the driest season, 81% below mean.

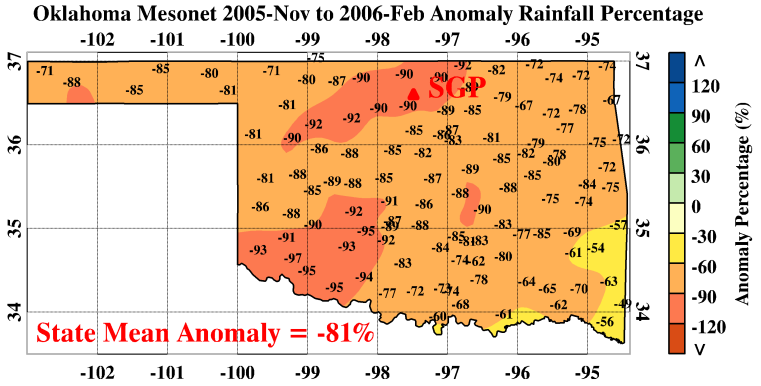
Summer 07 is second wettest season, 79% above mean.

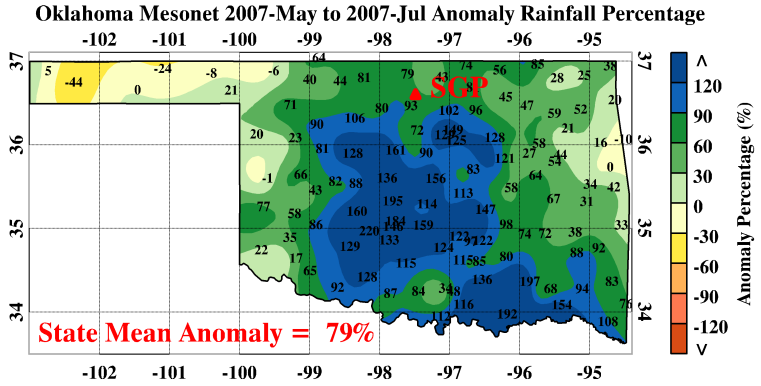






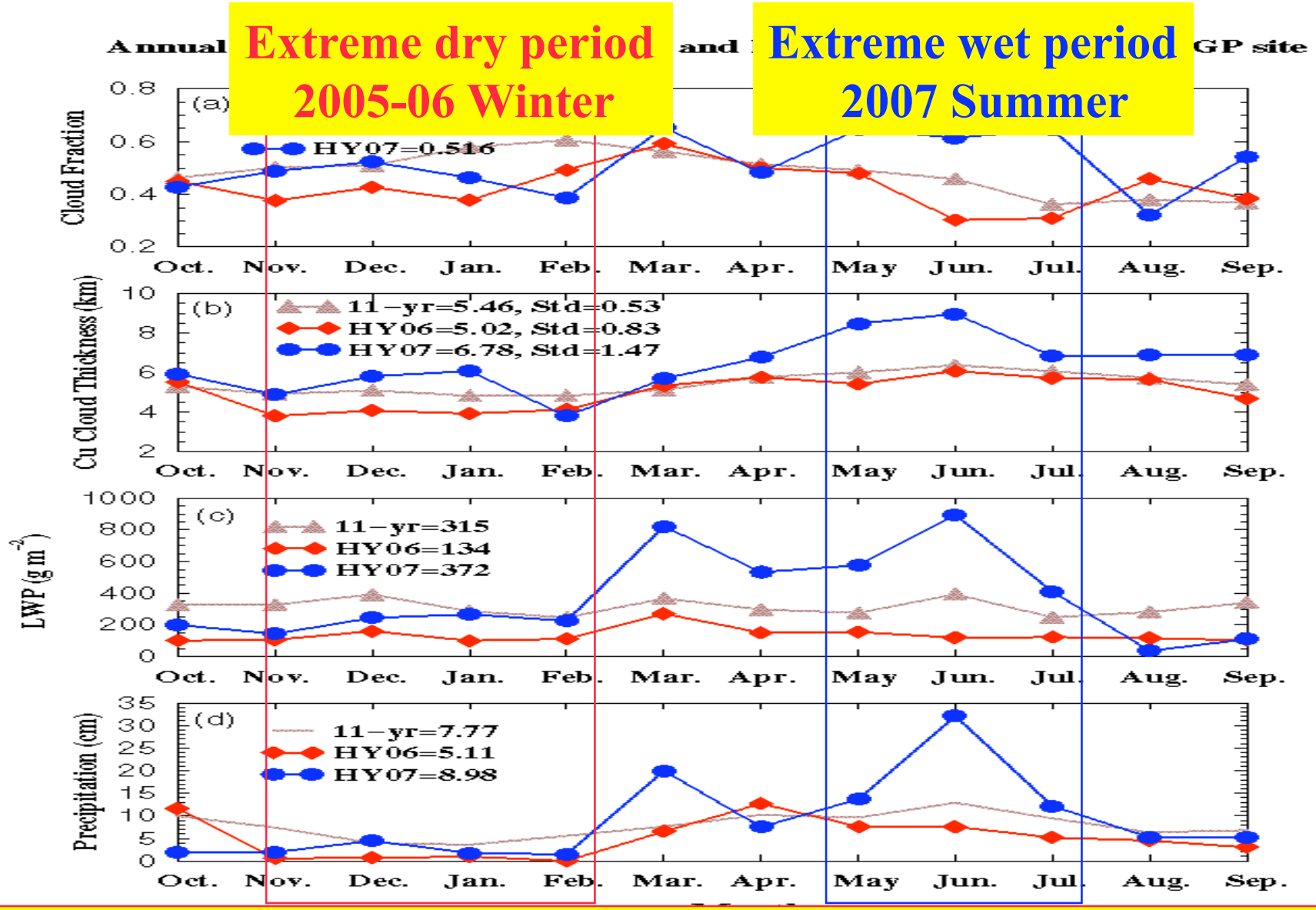






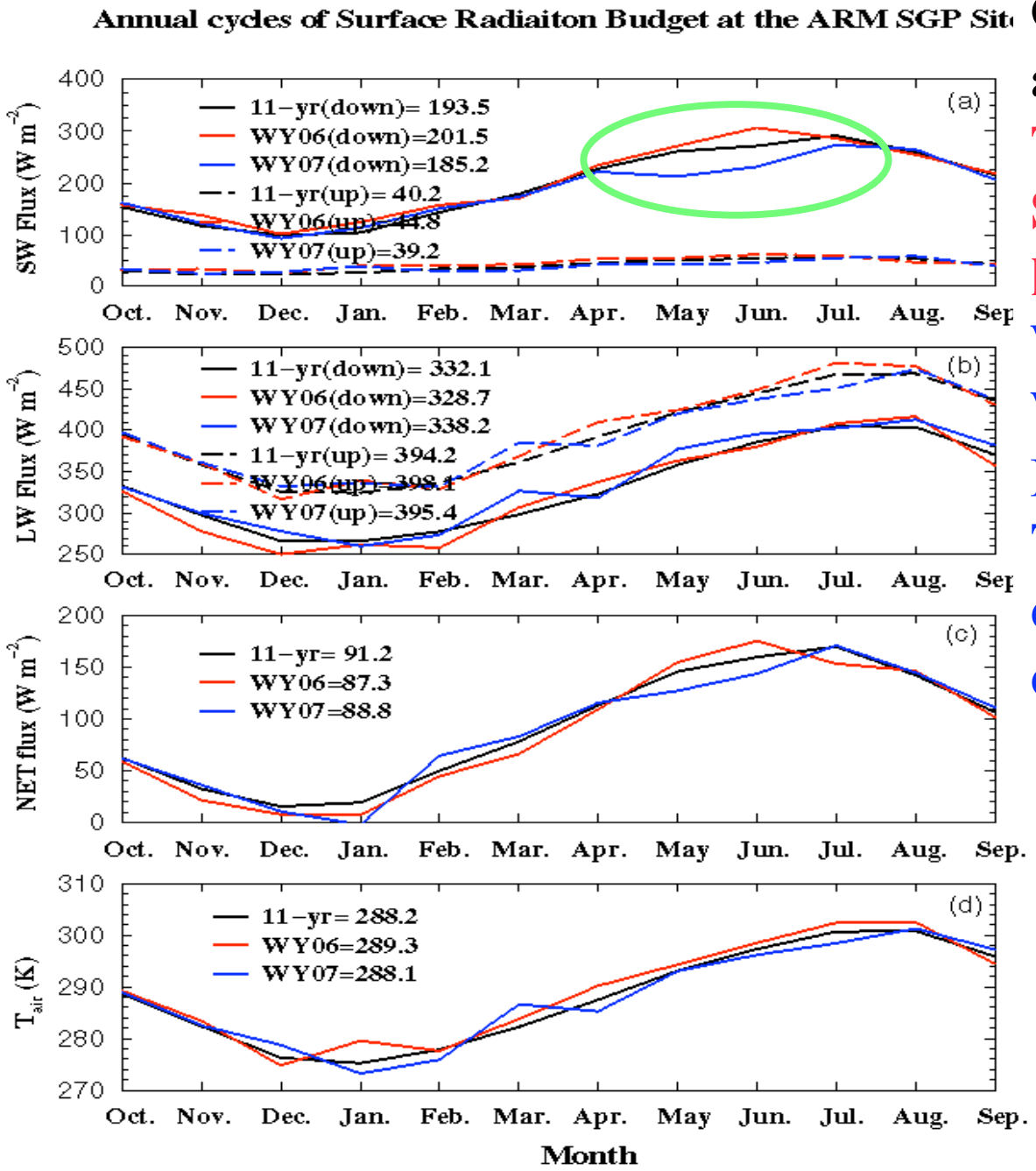
Question 2

2. What are the annual cycles of observed cloud-radiation-precipitation in HY06 and HY07?



1) Compared to the 11-yr averages, HY06 CF, CU cloud thickness, LWP, and Precip are much less, and those in HY07 are much more.

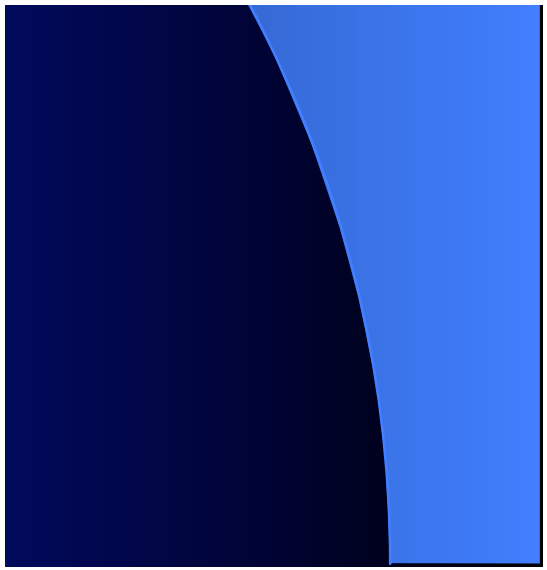
2) Precip strongly correlates with CF, Cu cloud thickness, and LWP



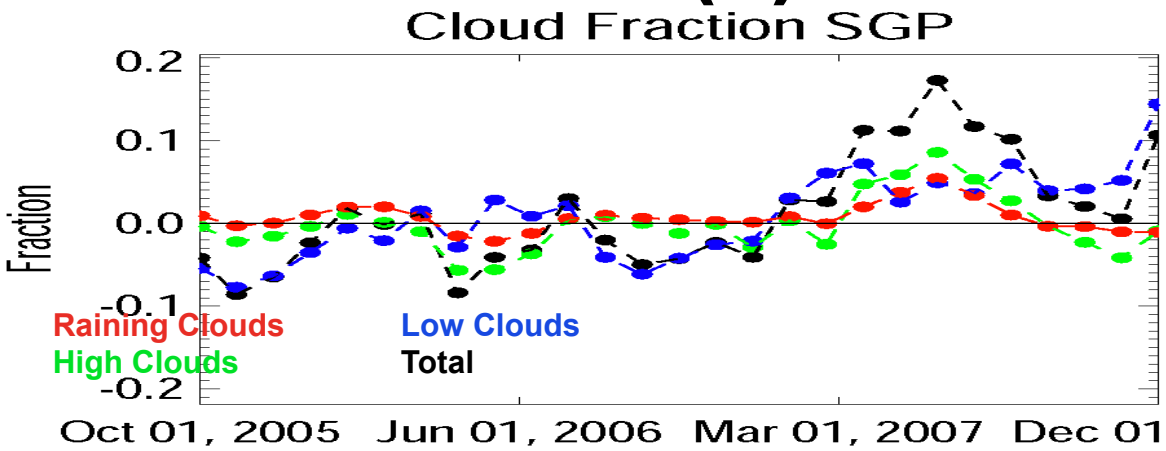
Compared to the 11-yr average (193.5 Wm^{-2}):

The HY06 downward SW flux is 8 Wm^{-2} higher , HY07 is 8.3 Wm^{-2} lower, and 36 Wm^{-2} lower during May-July 2007.

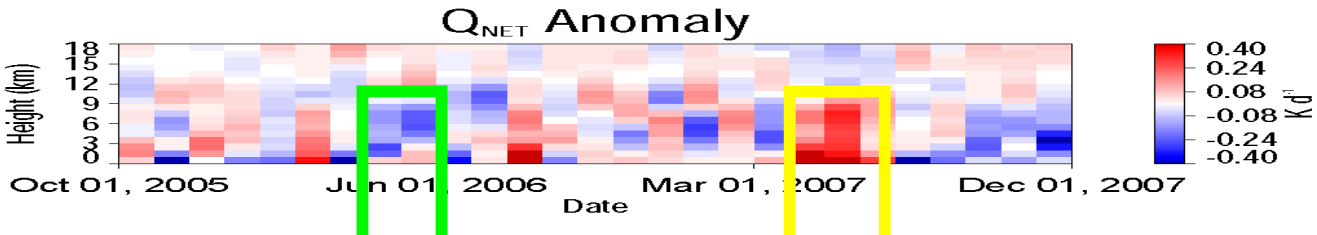
These results are very consistent with their cloud counterparts.



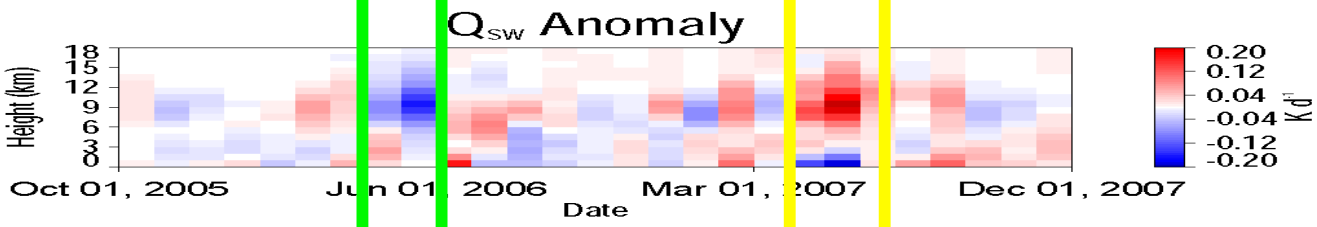
TRMM-based QR(z) at SGP



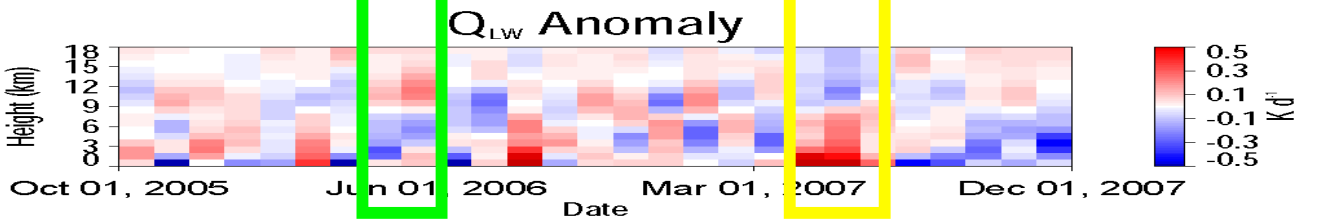
NET



SW



LW



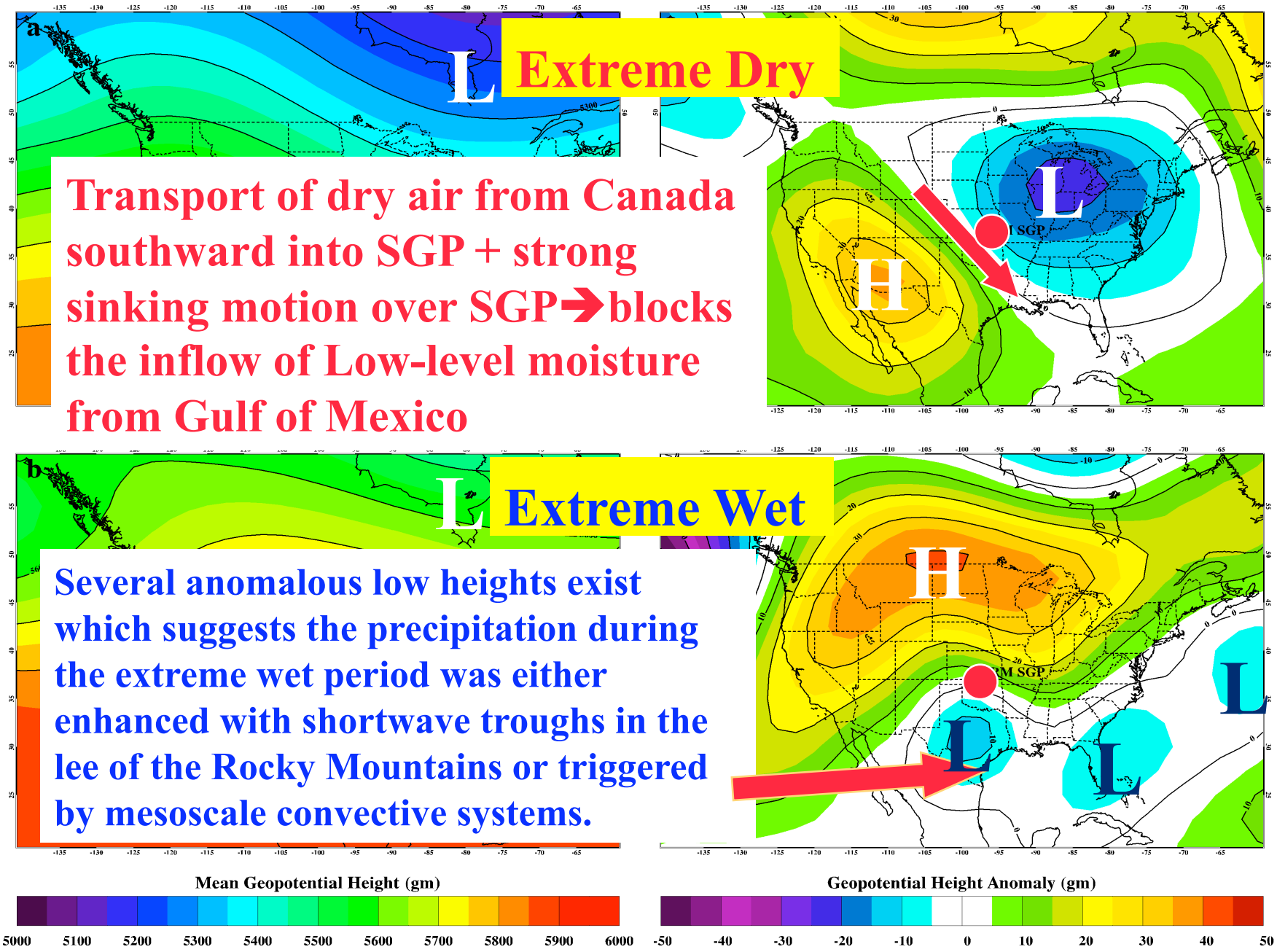
Dry Period <0 → cooling

Wet Period >0→warming

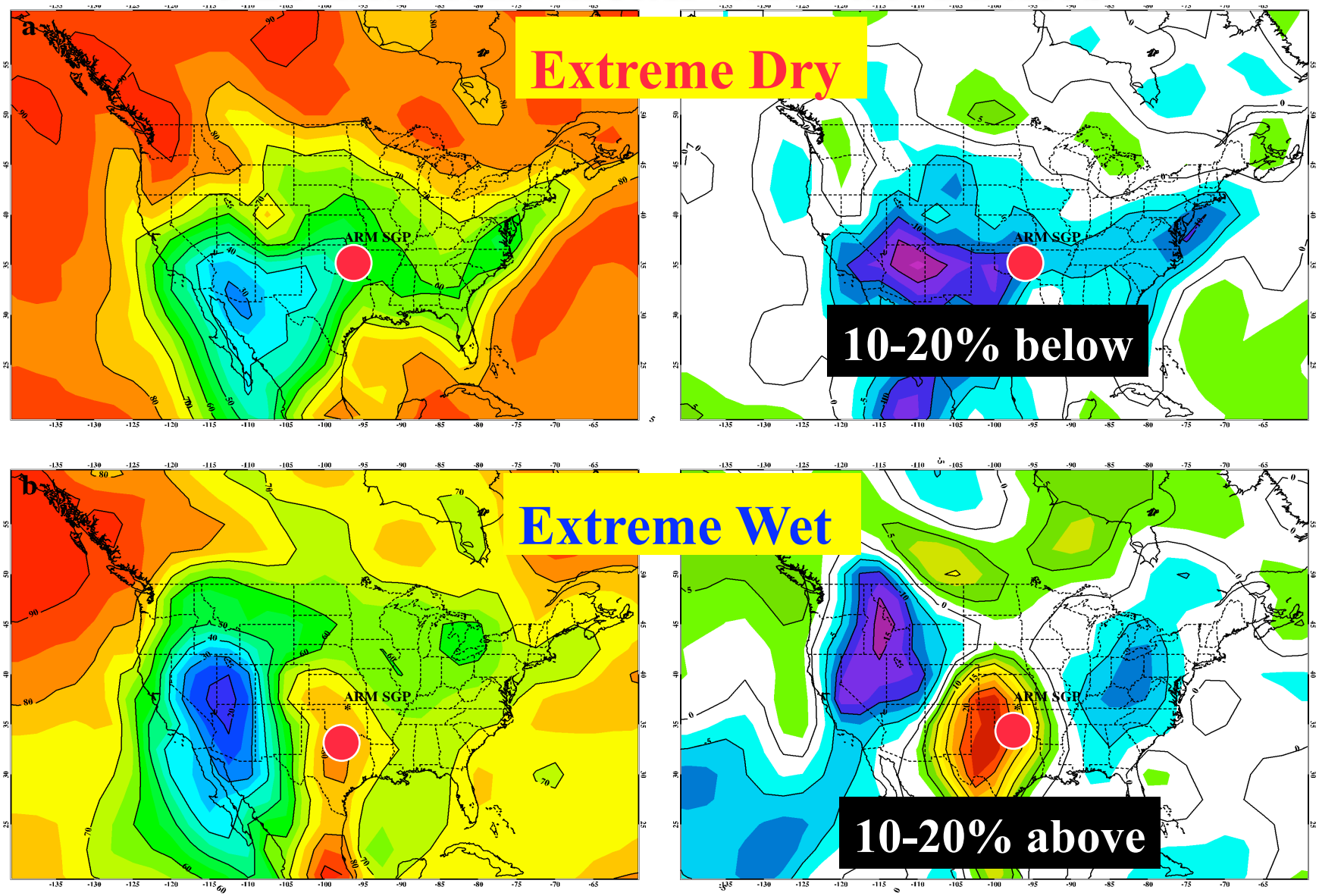
Question 3

To what extent do the large-scale dynamics play a role in controlling the SGP extreme events?

500mb Geopotential height Mean and Anomalies



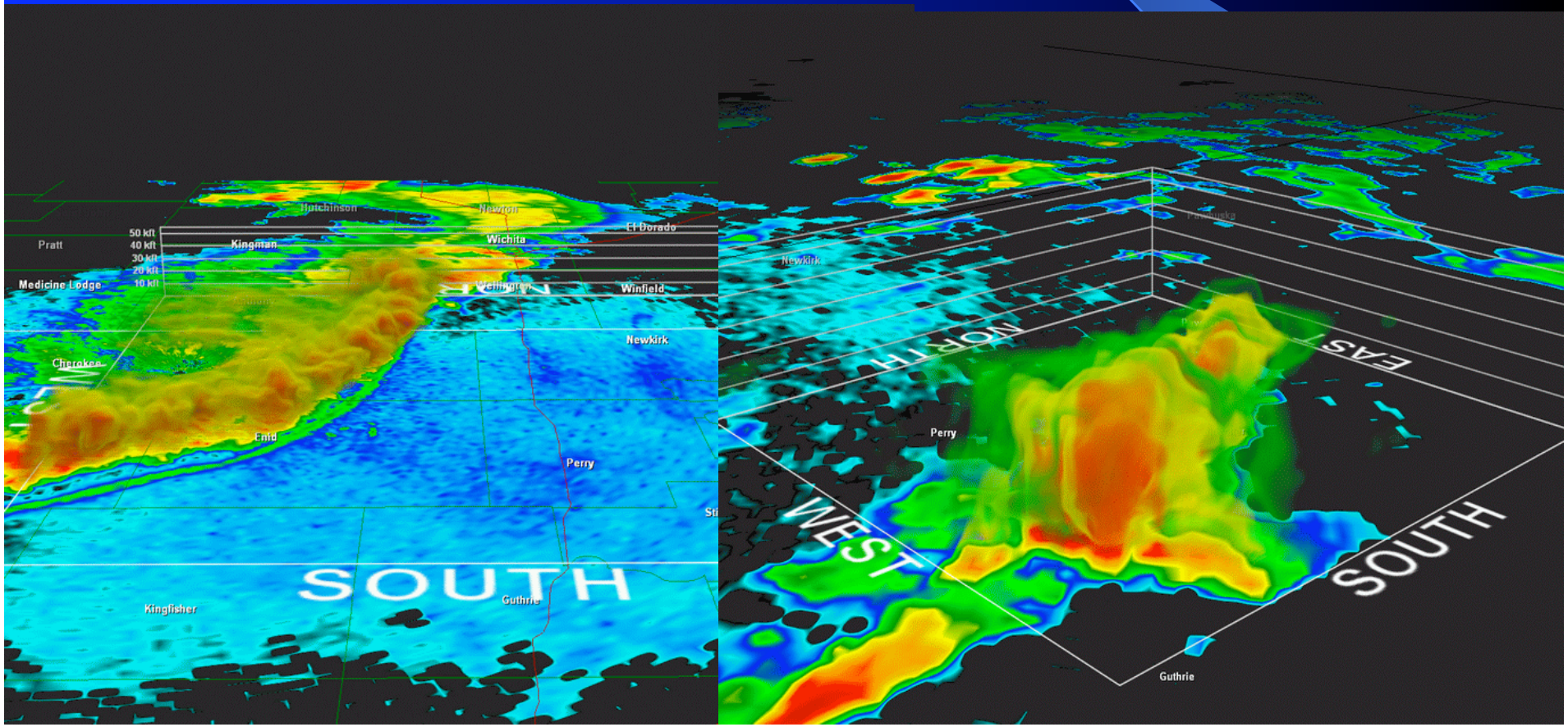
925 mb RH mean and anomalies



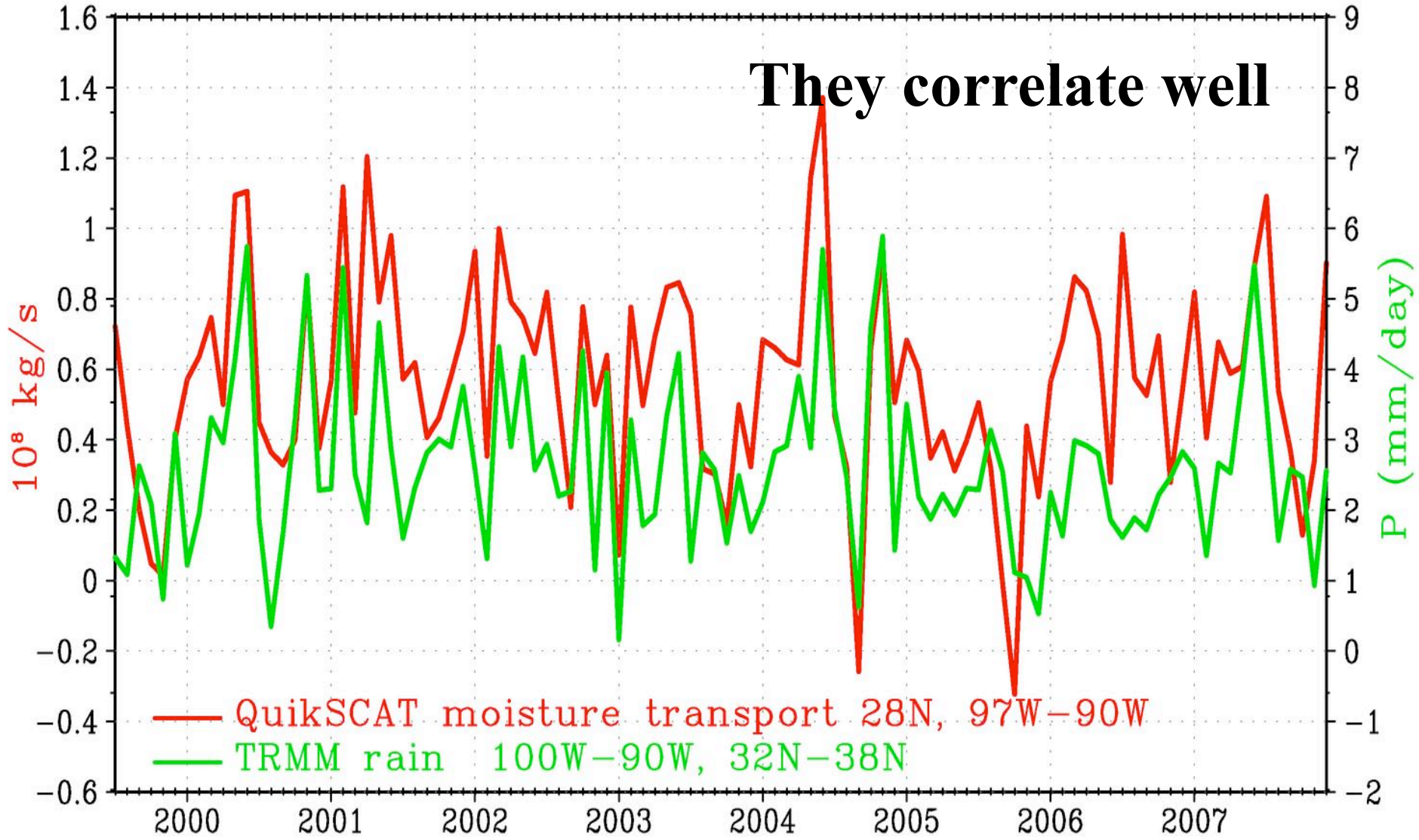
The dry area is much larger than wet area

2006 drought and 2007 flood contrast

- **Drought: refers to an unusually long period during which precipitation is below normal for a particular area (dominated by large-scale**

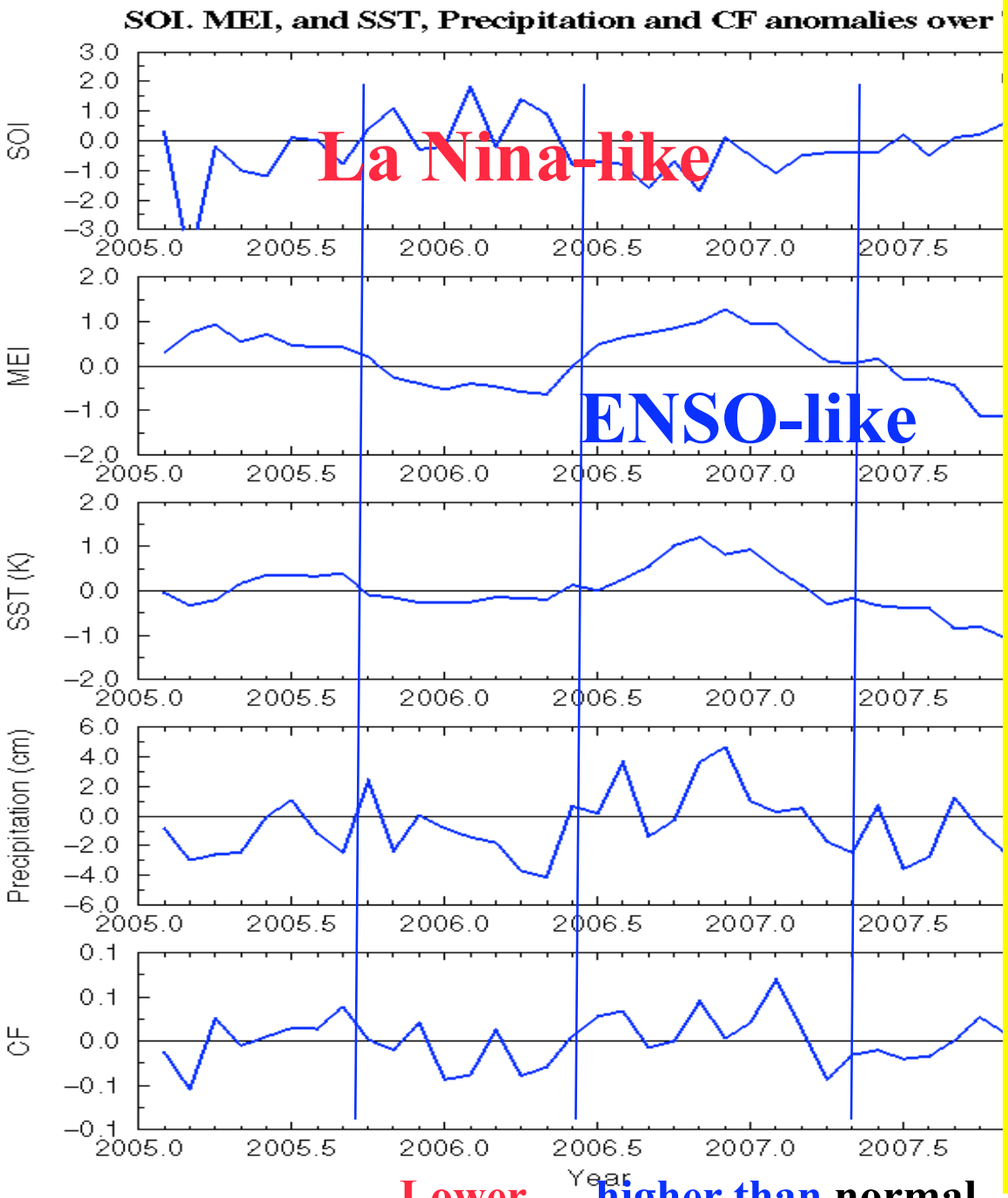


Relationship between SGP precipitation (green) and the vertically integrated moisture transport (red) from the Gulf of Mexico (positive for northward)



Question 4

How do the SGP extreme events (response) link with the Tropical East Pacific (TEP) SST and precipitation anomalies (forcing)?



Lower , higher than normal

➔The results during the winter 2005-06 show the existence of La Nina, such as SOI>0, MEI<0, and colder SST, less pecip. and CF over the TEP.

➔These results + Strong ridge over Western U.S. indicate the connection between TEP forcing and SGP drought (response).

➔The El Nino-like conditions have NOT relation with SGP extreme wet (local) event .

Summary

- This study investigates two extreme events occurred over the SGP through an integrated dataset, contrasts HY06 drought with HY07 flood and highlights their major difference, as well as the impact of large-scale dynamic pattern and TEP forcing on these extreme events.
- These results provide statistical information of clouds, radiation and precipitation from different data sets over the U.S. SGP during the period 1997-2007. These observational results can serve as a baseline for modelers to study the onset and demise of droughts and floods over the SGP region.
- These results, however, are only descriptions, not causes, of atmospheric circulations associated with droughts and floods. What causes this drought-flood related the change in atmospheric circulations, and what are the mechanisms responsible for the SGP droughts and floods, are still not quite clear. Therefore, it is necessary to include the modeling studies.
- Eventually, we can lead insights into the factors that are responsible for persistent drought and intensive flooding, and improve the predications of extreme events over the SGP, as well as over other climatic regions.

Commercial

- Midlatitude Continental Convective Clouds Experiment (MC^3E) will be conducted over the ARM SGP site during Spring 2011.

  It is funded as a joint program between DOE ARM and NASA GPM.

- ARM's main contribution to this experiment will be a sounding array and the Central Facility instrumentation, including the new radar systems, such as an X-band radar array, a scanning C -band system and a dual-wavelength scanning cloud radar Ka/W.

- NASA GPM Ground Validation will be leading the aircraft operations (one high altitude remote sensing aircraft, and one in situ aircraft) along with additional radar resources (ka/Ku and N-Pol) and a disdrometer network.

Commercial (cont')

Objectives of MC^{3}E:

1) To improve the GPM precipitation retrieval algorithms,
2) To improve the parameterization of convective clouds and precipitation physics in numerical models
3) To validate the surface and satellite radar retrievals using aircraft in situ measurements
4) To validate CRM simulations using the intensive observations during MC^{3}E field campaign.
4) To observe 3-D cloud and precipitation microphysics in deep convective cloud systems and their associated anvil clouds.
5) To determine radiative and latent heating rate profiles in precipitating cloud systems

Question: To what extent will our NEWS team involve in the MC^{3}E? (man power, flight hours, or processing data?)


Thanks for your attention!
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